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STANFORD PROGRAM IN COMPUTER-ASSISTED INSTRUCTION, PROGRESS REPORT 7, FOR THE PERIOD APRIL 1, 1967 TO JUNE 30, 1967.

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THIS REPORT DESCRIBES THE PROJECTS IN COMPUTER-ASSISTED INSTRUCTION CONDUCTED AT THE STANFORD LABORATORY FOR COMPUTER-ASSISTED LEARNING AND TEACHING AND AT THE STANFORD-BRENTWOOD COMPUTER-ASSISTED INSTRUCTION (CAI) LABORATORY. THE MAJOR ACTIVITIES, WHICH ARE REPORTED FOR THE PERIOD FROM APRIL 1 TO JUNE 30, 1967, ARE (1) READING AND MATHEMATICS AT BRENTWOOD, (2) A TELETYPE PROGRAM IN ELEMENTARY MATHEMATICS INCLUDING DRILL AND PRACTICE, (3) A TELETYPE PROGRAM IN MODERN ALGEBRA AND SYMBOLIC LOGIC, AND (4) A PROGRESS REPORT ON THE DEVELOPMENT OF A COMPUTER-BASED FIRST-YEAR COURSE IN RUSSIAN. A REPORT ON SYSTEMS AND OPERATIONS FOR BOTH THE STANFORD-BRENTWOOD 1500 SYSTEM AND THE STANFORD PDP-1 SYSTEM IS INCLUDED. ALSO DESCRIBED ARE ACTIVITIES PLANNED FOR THE NEXT REPORTING PERIOD AND A RECORD OF PERSONAL CHANGES. (RP)

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PROGRESS REPORT 7

STANFORD PROGRAM IN COMPUTER-ASSISTED INSTRUCTION

FOR THE PERIOD

APRIL 1, 1967 to JUNE 30, 1967

NATIONAL SCIENCE FOUNDATION GRANT NSFG-18709

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INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES

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I. Major Activities of the Reporting Period

A. Brentwood

1. Mathematics

The children who came to the CAI Laboratory for instruction in mathematics followed the schedule established at the beginning of the year. There were four groups of 11 to 16 children. Each group spent 25 minutes in the Laboratory, spending most of its time on the programmed lessons.

Enrollment and absences. In the period from April 1 until the end of school on June 14, the enrollment was relatively stable. Three children enrolled during this period, and the only withdrawal occurred four weeks before the end of school. On June 14, the total enrollment was 51.

There were several absences of a week or more because of either mumps or chicken pox, and one child was absent for 12 days because of severe burns. Other absences were infrequent.

Procedure for handling new students. On the first day of a child's enrollment, the laboratory classroom teacher worked with him individually in the classroom to determine where in the mathematics program the child should be placed.

There were always questions from a new child about where all the other children were going and what they were going to do. The new child was told the other children used special machines to help them learn arithmetic, and that on the next day, he would also be able to use a machine.

On the second day, the new child was assigned to a student station, and a proctor explained to the child the workings of the earphones and the light pen, and how to touch the happy face below his name to start the lesson. As soon as it was clear that the child understood how to respond, the proctor left the child to work independently with the direction to ask for help at any time. The proctor was also alert to any change in answer mode, for example, answering by typing instead of by pointing with the light pen. The child was given further instruction as soon as he came to such a lesson.

None of these students had any difficulty in starting work with programmed material at this time of year. Their progress was as good as children of comparable ability, who had been in the project for the entire year.

Terminal room procedure. The terminal room procedure was essentially the same as for the previous reporting period. There were three proctors whose primary duty was to help individual children, and one proctor who was responsible for handling mechanical problems.

Two types of equipment were used by the children in connection with the material presented on the terminals. Rulers were used to measure drawings on worksheets that were coordinated with given lessons. The children typed the answers to various questions asked about these drawings.

Beads strung on heavy wires were made available for the children to use in finding sums and differences. The children requested beads from a proctor if they encountered a lesson in which they wanted objects to count. As the children became more assured in addition and subtraction, the requests for beads decreased.

A significant change was made in the method of handling proctor calls. A proctor call occurs when a child fails to meet the criterion established for a given lesson. A proctor call also occurs when a new audio tape or film reel is needed at a particular station. When the children complete their lessons without remedial branches, audio tape and film reel changes occur frequently, often as many as one per child per day. Thus, proctor calls were at times so numerous that some children had to wait before receiving help. To alleviate this problem, the children whose proctor calls were for lesson failures were sent to the laboratory classroom with a note telling on what particular concept the child needed help, unless the failure was a simple matter of not understanding the method of answering.

Classroom procedure. The classroom procedure was changed considerably. As most of the children began to spend the entire period doing lessons on the machines, the classroom teacher often functioned as an additional proctor.

However, when the number of proctor calls increased as described earlier, the classroom teacher remained in the classroom to help those children who had lesson failures. She gave help for whatever period of time was necessary. In some cases, a child was able to return to his station within five minutes. In other cases, it was necessary to help a child every day for a week or more before he was ready to return to the programmed material.

This was quite an efficient way of handling proctor calls for lesson failures. The load on the proctors was substantially reduced, the classroom teacher was able to work with a number of children at a time without difficulty, and most important, the children very much appreciated receiving help with their problems for as long as necessary.

This procedure required that the classroom teacher be very familiar with the programmed material, anticipate the areas in which the children were most apt to need help, and prepare in advance materials on a wide variety of topics.

Programmed curriculum. During the period from April 1 to June 24, most of the children were doing programmed lessons on addition and subtraction to 10; some progressed through sums greater than 10. Other topics included counting dimes and pennies as an introduction to the numbers from 10 to 20 and as readiness for the study of place value; number words zero through ten; one half of an object; measuring isolated line segments and sides of polygons; recognition of similar figures in various sizes and positions; and concave figures.

By far the most difficult lessons were those in addition of the form,

$$a + \_\_ = c \quad \text{or} \quad \_\_ + b = c.$$

All but three children required additional classroom help with this topic.

Table 1 shows the number of children in each book during a given week.

Insert Table 1 here

Those children who advanced farthest by the end of the year had done few remedial lessons during the entire year, while the students who completed the fewest number of books spent a great deal of time on remedial work.

Laboratory classroom curriculum. There were five days when all children spent the entire period in the classroom. During these periods, the children studied telling time to the hour and counting pennies, nickels and dimes. Considerable work with real clocks and real coins was done, as well as a small number of written exercises on these topics. In addition, the curriculum included story problems, in which the teacher told the story and the children responded verbally or in writing. To solve the story problems, it was necessary to apply many of the concepts learned throughout the year.

A few of the children who worked most quickly occasionally finished all of the available programmed material and had to remain in the classroom for one or more days while additional material was being readied. During their time in the classroom, these children studied constructive geometry using material from Sets and Numbers, Grade 1, by Patrick Suppes and from Geometry for the Primary Grades, by Newton Hawley and Patrick Suppes.

Testing. During May, two tests were given to each child in the project. The group test, Stanford Achievement Test, Primary I Battery, Form W, was given to seven classes throughout the school district as well as to the two classes in our project. The individual test, School Mathematics Study Group Test for Culturally Deprived Children, was given only to the children in this project.

The analysis of these test data will be made during the summer. No results are available at this time.

2. Reading

Remedial second-grade students. Thirteen remedial reading students from two second-grade classrooms were brought in the system on a daily basis during this reporting period. They adapted quickly to the environment and their progress was satisfactory. The classroom teachers reported an increase in interest and application to classroom reading instruction by the students involved in the program. Detailed comments about their rate of progress will be found in the following section.

Analysis of student performance. Some gross preliminary analyses were made of student performance as that performance was reflected in the weekly reports. The analyses and findings have been reported in some detail in Wilson and Atkinson (1967)*. The following is a summary of those findings:

a. no sex differences were found in overall rate of progress.

b. statistically significant sex differences (i.e., girls excelling boys) in accuracy of response were found in only one problem block: word-list learning, which is essentially a rote-memory, paired-associate learning task.

Spread on main line. Certain problems comprising a central core within the lesson material are considered main-line problems in the sense that they are problems which each student must master. A student may be branched around blocks of main-line

* Computer-based instruction in initial reading: a progress report on the Stanford project. Tech. Rept. 119, Psychology Series, Institute for Mathematical Studies in the Social Sciences, Stanford University, August 1967.

Table 1. Number of Children in Each Book of Programmed Mathematics Curriculum, Shown by Weeks.

Book	April 3-7	April 10-14	April 17-21	April 24-28	May 1-5	May 8-12	May 15-19	May 22-26	May 29- June 2	June 5-9	June 9-1
6C	3	1	1								
7A	4	1									
7B	2	2	2	1	1						
8	1	2	2	2*		1	1	1	1		
9A	2	3	2	3	1						
10	1	1	3	5		1				1	1
9B		1		1	4	1					
14A		1	2	2	4	1	1				
14B	1				1	6	3				
15A	6	1			1						
15B	4		1			1	1				
16	14	7	1		2		5	5	2	1	
17A	6	6	8	7	1	3	1	5	4	4	4
17B	6	20	8	5	2		2	1	3	3	3
18A		4	8	11	6**	2	2	2	3	2	1
18C			12	7	5	5		5	1	1	2
18B				8	14	6	7	3	5	2	2
19A					4	8	4	4	3	3	3
19B					5	8	4		2	3	1
20A					1	4	6	13	7	3	4
20B					1	5	9	6	5	7	8
21A						1	2	1	1	1	1
21B							5	5	5	1	1
22A								2	6	6	
22B									4	4	9
22C										2	1
23A										1	2
23B										4	1
24A										1	4
24B										2	2
25A											
25B											2

* Two children enrolled, started in Book 8.
** One child enrolled, started in Book 18A.

problems by successfully passing certain screening tests. On the other hand, a student may be branched to appropriate remedial material if he has difficulty with these central problems; but in every case, he is returned to that set of main-line problems for which remedial material was introduced.

Each lesson contains an average of 125 main-line problems. Therefore, the number of lessons completed by a student may be used as an index of the number of main-line problems successfully completed. Figure 1 shows the number of main-line problems completed each week by the fastest, slowest and median student. Figure 1 was derived by identifying the student who had completed the most lessons on the final student progress report for the week of June 14 and, from the same report, identifying the median student and the slowest student, considering only those students who had begun the program on November 15, 1966. New students who had moved into the school and the remedial second-grade students are not considered in the derivation of Figure 1, or in any of the data reported here.

Insert Figure 1 about here

The year ended with a difference between the fastest and slowest student of 4,125 problems completed. The inter-quartile range was 1,375 problems and the median student completed 2,625 main-line problems. There was, however, a rather wide variation in the amount of time spent on the system by the students. In order to take this variation into account, a rate-of-progress score was computed by dividing the number of problems completed at the end of the year by the number of sessions that the student had on the system. The cumulative rate of progress for the highest, lowest, and median student is shown in Figure 2, expressed in terms of number of main-line problems completed per hour of instruction. The range in rate of progress was between 35 problems per hour for the slowest student to 170 main-line problems per hour for the fastest student. The inter-quartile range is 45 to 110 with the median at 75 problems per hour.

Insert Figure 2 about here

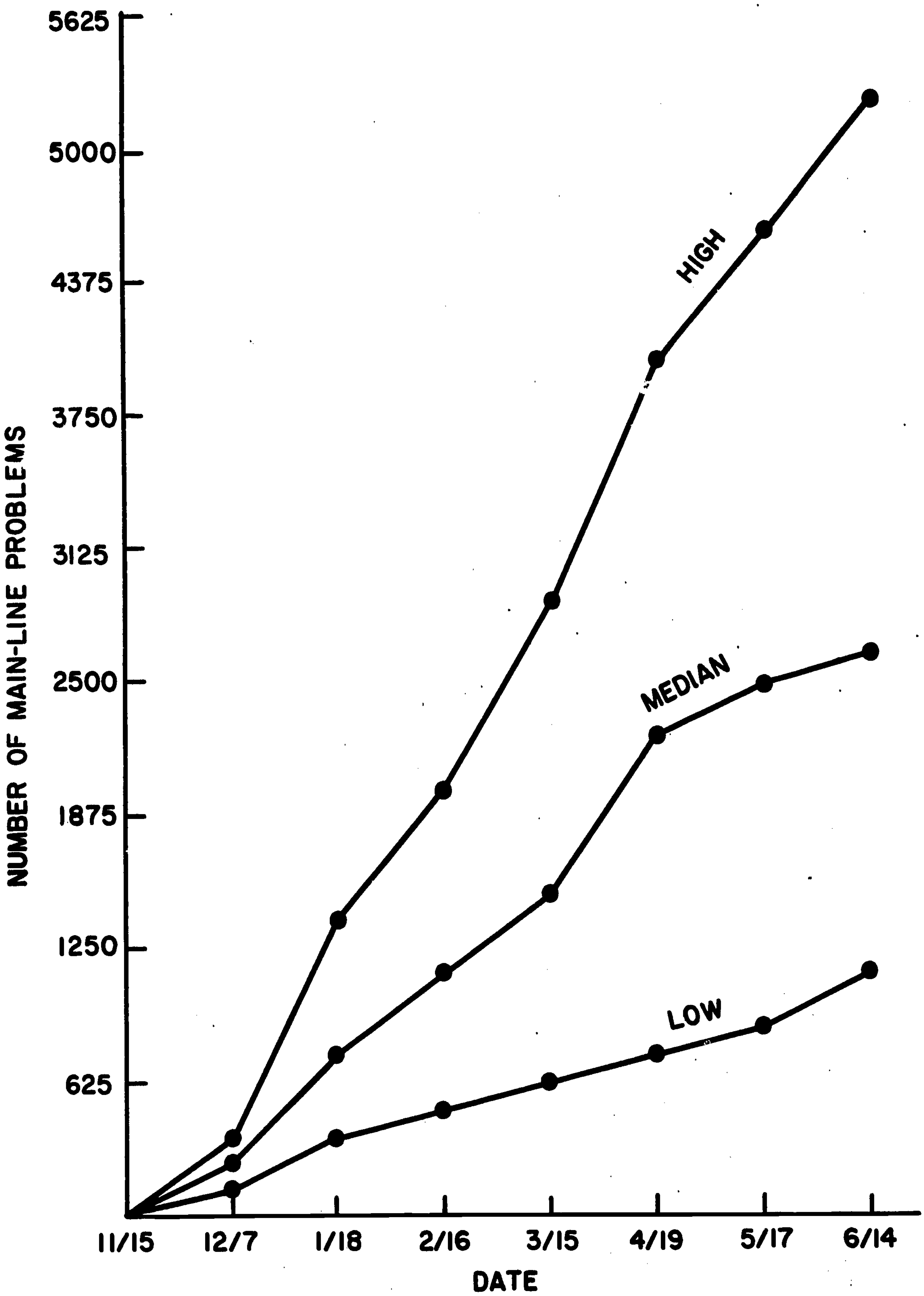

Figure 1. Number of main-line reading problems completed each week by fastest, slowest, and median students.

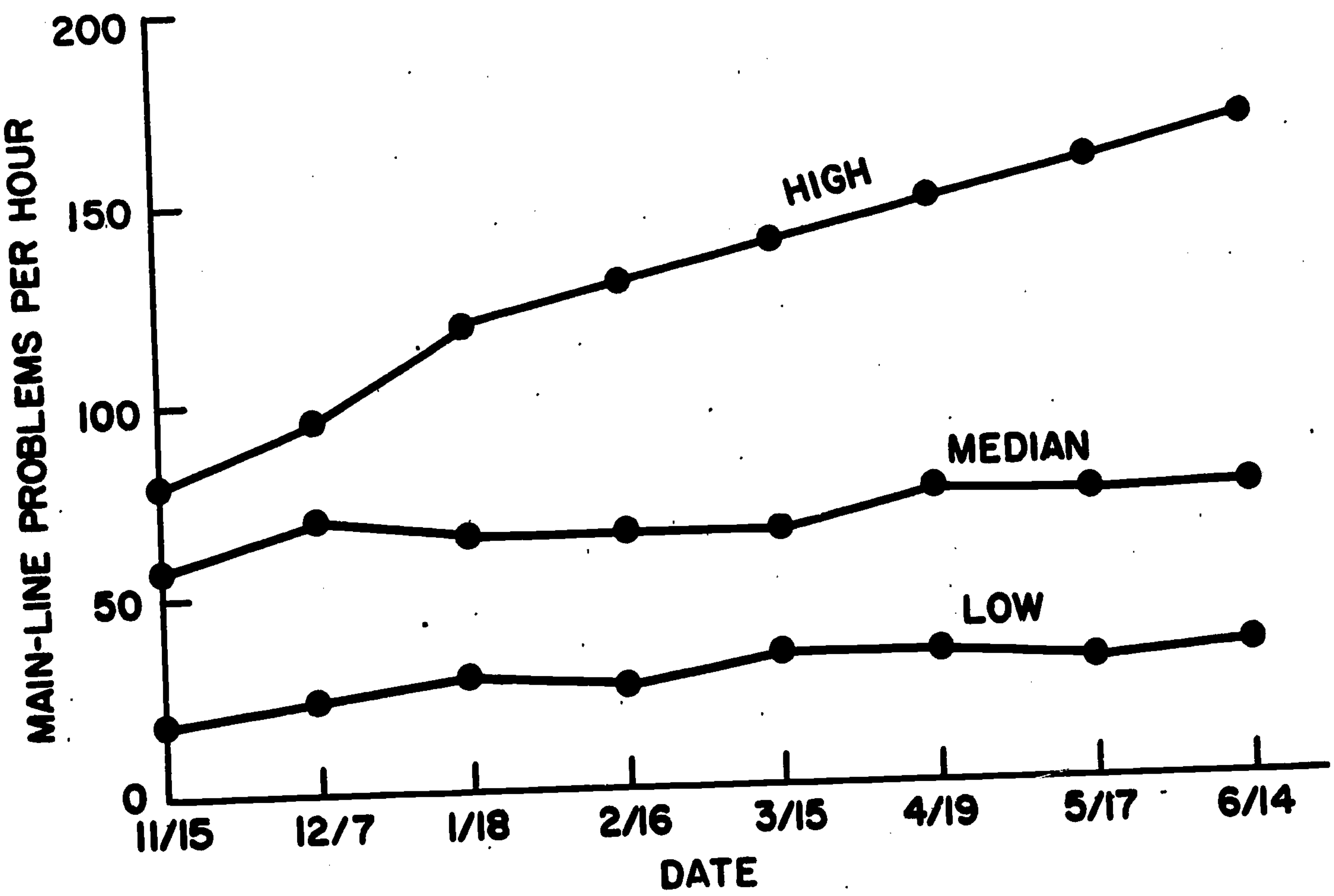

Figure 2: Number of main-line reading problems completed by highest, lowest, and median students, per hour of instruction.

A graph of the cumulative rate of progress for the remedial second-grade students after eight weeks of instruction is compared in Figure 3 with that of the regular first-grade students at the end of their first eight weeks of instruction. The range of the second-grade remedial students was from 58 to 131 main-line problems per hour with the median at 104. It is interesting to note that the bottom of the second-grade remedial distribution falls just under the median of the first-grade distribution.

Insert Figure 3 about here

From the standpoint of both the total number of main-line problems completed during the year and the rate of progress, it is clear that the CAI reading curriculum is accounting for individual differences on at least one dimension (i.e., the movement of the individual student through the lesson material). The differences noted in Figures 1 and 2 must not be confused with a variation in rate of response. The differences in the rate of response between students was very small; the average rate was approximately four responses per minute. The differences in the total number of main-line problems completed and in the rate of progress can be accounted for by the amount of remedial material, the optimization routines, the number of corrections, and the number of accelerations for the different students.

Sex differences. The weekly progress report data were examined for evidence of of sex differences in overall rate of progress and accuracy of response. Briefly summarized, the analysis indicated that:

a. there were no sex differences in rate of progress, and

b. statistically significant sex differences (i.e., girls excelling boys) appeared in only one problem block: the word-list learning block which is essentially a rote-memory paired-associate learning task.

A complete discussion of this analysis is reported in Wilson and Atkinson (1967)*.

Achievement tests. Even though this first year's operation of the system has been viewed as essentially an extended debugging process, we felt that a

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* op. cit.

comprehensive end-of-the-year testing program might yield some interesting insights into the potential impact of the program on overall reading achievement. Accordingly, a battery of tests was assembled which would measure achievement in each of the major areas of reading behaviors taught at the first-grade level. The behaviors identified and included in the testing program were:

a. Identification of letter and letter-strings.

b. Acquisition of an initial sight vocabulary.

c. Acquisition of word decoding skills:

(1) initial consonants

(2) initial consonant clusters

(3) medial short vowels

(4) final consonants

d. Acquisition of reading comprehension skills:

(1) word meaning

(2) syntax or form class for sentence comprehension

(3) paragraph comprehension:

a. main idea

b. recall of facts

Wherever possible we chose standardized tests of the reading behavior to be evaluated. In several cases, the tests only approximated what we were trying to measure, or they were not pure tests of a single reading behavior. As far as we could determine, none of the available test batteries included tests of all the reading behaviors listed above. It was particularly difficult to find group-administered tests measuring a child's ability to decode words and the child's knowledge of syntax or form class behaviors. Therefore, Ruth Hartley of the project staff devised tests of these behaviors.

The tests which were chosen for this test battery were derived from the following sources:

a. Gates-MacGinitie Reading Test, Primary A, Form 1, 1965 edition.

b. California Reading Test, Lower Primary, Form W, 1957 edition with 1963 norms.

c. Stanford Achievement Test, Reading Sections, Primary 1 Battery, 1964 edition.

d. Project developed tests.

The students in the CAI mathematics program provided an ideal control group. Analysis of the individually administered Stanford-Binet I.Q. tests at the beginning of the school year indicated that the students in the reading program and the students in the mathematics program may be considered as two samples from the same population. The mean I.Q. for the reading group was 92.5 (standard deviation 15.6), and the mean I.Q. for the mathematics group was 91.8 (standard deviation 14.6). Any "Hawthorne effect" which might be induced by the CAI experience is controlled, since the mathematics students had an equal amount of time on the system but for a different subject matter. The mathematics students received a program of reading instruction which might be termed traditional, relying primarily upon the Ginn and the Allyn and Bacon first-grade readers.

All tests, with the exception of the Stanford Achievement Test, were administered by members of the project staff, assisted by graduate students from the School of Education at Stanford University. Each testing team, consisting of a project staff member and a graduate student, administered a given test for all of the students in order to eliminate tester effects. The Stanford Achievement Test was administered by the individual classroom teachers as part of the testing program of the State of California. All tests were conducted within the normal classroom setting. The testing program was carried out during May, 1967.

Overall results. The results of each of the above tests and their major subsections were examined in a series of three-way analyses of variance (treatment, high/low I.Q., sex). No significant interactions were found in any of the analyses. The expected significant differences on the I.Q. and sex variables were found throughout the tests and are of little interest here. The means and standard deviations for each test for the experimental and control groups are shown in Table 2. It is interesting to note that with the exception of two cases (Stanford Achievement Test, paragraph reading and total score) the direction of differences between the means is in favor of the experimental group.

Insert Table 2

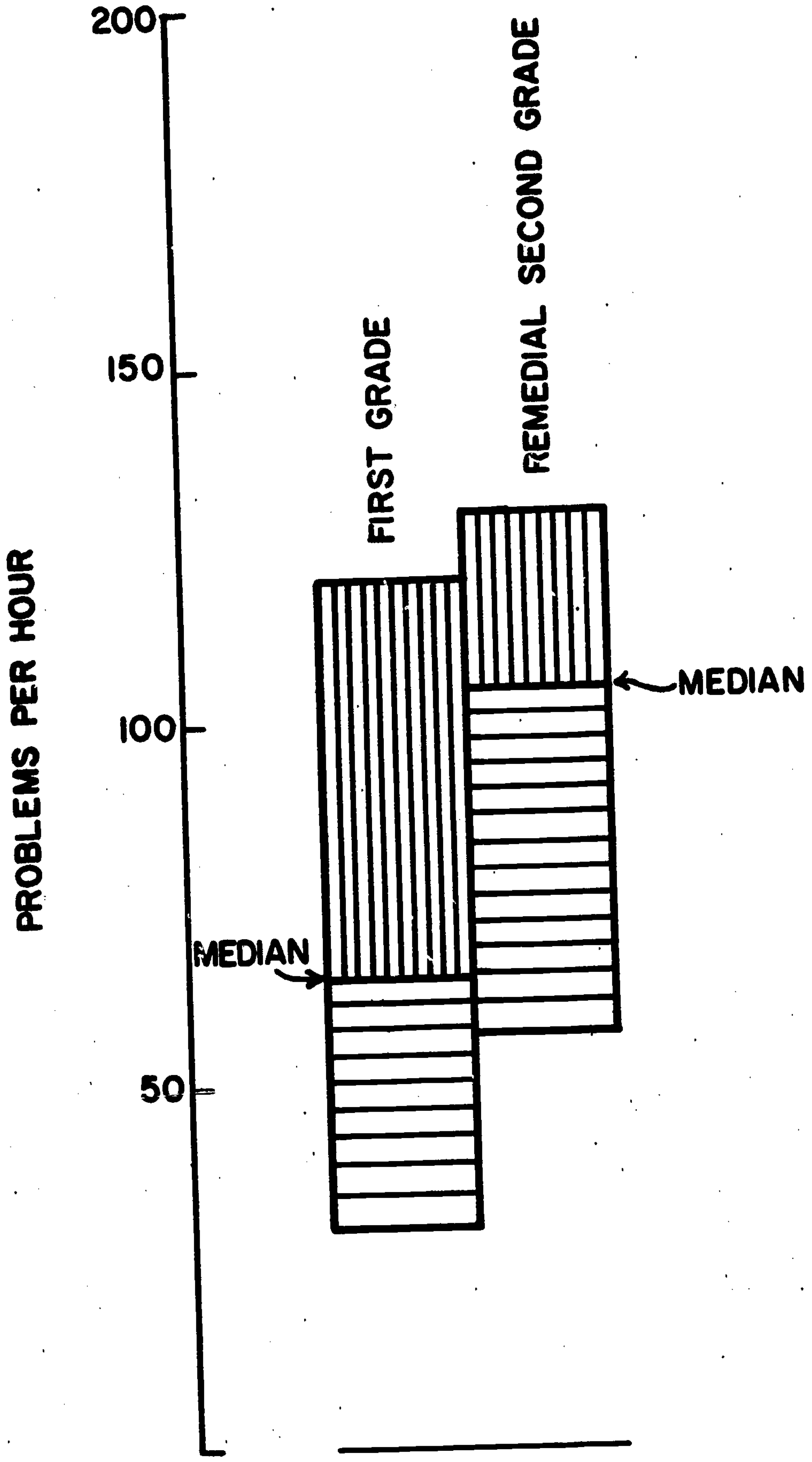

Figure 3: Comparison of the distribution of rate of progress of first-grade and remedial second-grade students after eight weeks of CAI reading instruction.

Table 2

Means and Standard Deviations: Major Test Sections

	Experiment		Control		Significance Level
	Mean	S.D.	Mean	S.D.	
Gates*					
Vocabulary	41.1	9.26	39.3	9.01	N.S.
Comprehension	39.5	8.93	38.8	9.12	N.S.
Total	38.5	9.07	37.4	9.02	N.S.
C.A.T.*					
Vocabulary	45.9	1.76	38.1	2.02	$p < 0.01$
Comprehension	41.4	2.51	40.6	2.16	N.S.
Total	45.6	0.58	39.6	1.01	$p < 0.01$
S.A.T.*					
Word Reading	40.3	4.84	40.0	2.44	N.S.
Para. Reading	36.0	9.73	38.5	4.07	N.S.
Vocabulary	41.7	3.89	40.7	2.05	$p < 0.01$
Word Study	45.9	3.72	44.9	2.50	$p < 0.01$
Total	44.2	5.89	44.6	3.76	N.S.
Project**					
Form Class	8.6	5.23	6.4	4.95	$0.01 < p < 0.05$
Vocabulary	17.7	4.16	15.7	4.27	$p < 0.01$
Pronunciation	11.28	10.21	4.94	7.66	$p < 0.01$
Phonetic Discrim.	14.06	20.07	10.63	15.32	$p < 0.01$

* Standard Scores: M = 50, S.D. = 10

** Raw Scores

The test battery may be divided into two major categories:

(a) tests designed to evaluate the goals and linguistic orientation of the CAI program, and

(b) tests designed to evaluate the outcomes of a quite different approach to initial reading (i.e., the traditional basal reading series approach). Differences between the means of each of the project developed tests were statistically significant, and in the pronunciation test, were fairly dramatic. Statistical significance was also achieved in three of the eight sub-scales of the standardized tests. Two of those sub-scales, however, the vocabulary section of the California Achievement Test and the word-study skills section of the Stanford Achievement Test, were composed of a series of tests of sub-skills. It was necessary, therefore, to investigate the possibility that large differences on one or two of the sub-skills might be exerting an influence powerful enough to produce significance in the sub-scale as a whole. Accordingly, the scores on each test of sub-skills were examined in the same three-way analysis of variance as described above. The results may be seen in Table 3. The significance levels held in all four of the sub-skills for the word-study section of the Stanford Achievement Test and in three of the five tests of sub-skills in the vocabulary section of the California Achievement Test.

Insert Table 3 about here

The impact of this year's CAI instruction on reading performance may be more readily visualized when the results are tabulated by reading behaviors which were measured in the evaluation program, as in Table 4. Eight of the nine tests of decoding skills resulted in differences in favor of the CAI group which were significant at the .05 level, and in six of those eight tests the significance was at the .01 level or beyond. Three of the tests of comprehension at less than the paragraph level resulted in differences in favor of the CAI group which were significant at the .05 level. No significant differences were found in the tests of comprehension at the paragraph level.

Insert Table 4 about here

The above results are most encouraging for the potential impact of CAI on initial reading in light of the fact that even the fastest student in this year's program progressed only a small fraction of the way through the first year's curriculum (Figure 4). The curriculum was designed with the expectation that the able student would be able to complete approximately 180 lessons in the first year. As may be seen in Figure 4, the top student in this year's program completed only approximately 22 per cent of the expected total number of lessons. The average student in this year's group completed only 11 per cent of the total first year's program.

Insert Figure 4 about here

Table 5 shows the sequence of consonant and vowel patterns presented at the eight lesson levels. The first eight lessons on Level III were occupied primarily with ec and cec patterns. Thus, a comparison of Table 5 and Figure 4 will verify that no student in this year's run had been exposed on the CAI system to more than seven basic patterns: ac, cac, ccac, ic, cic, ec, and cec (where c stands for any consonant and each vowel is specified). This

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Insert Table 5 about here

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minimal exposure was sufficient to produce a significant increase in performance in nine out of the ten tests of decoding skills. Some transfer of learning is evidenced by the fact that six of those nine tests were commercial standardized tests whose vocabulary and word patterns were not based on the Stanford CAI program. Transfer of training is also born out by the observations of the classroom teachers involved, particularly the teacher of the low maturity group. She has reported that a noticeable percentage of the low group of students were discovering word patterns in their classroom reading instruction and generalizing those word patterns in the attack of new words.

The most consistent results were found in the area of decoding skills, which is exactly the area of initial reading which is handled in greatest detail in the Stanford CAI program. On the other hand, results in the comprehension tests were mixed, with no significant differences being found in tests

Table 3

Means and Standard Deviations: Sub-scales

	Experiment		Control		Significance Level
	Mean	S.D.	Mean	S.D.	
<u>C.A.T.</u>					
Vocabulary:					
Word Form	18.3	5.13	15.0	5.30	$p < 0.01$
Word Recognition	13.4	4.87	11.7	4.50	$0.01 < p < 0.05$
Opposites	6.2	2.96	5.7	2.70	N.S.
Picture Association	8.2	2.92	6.8	2.26	$p < 0.01$
Letter Recognition	21.2	5.17	20.6	6.20	N.S.
<u>S.A.T.</u>					
Word Study:					
Audio Perception					
Beginning Sounds	9.87	2.71	8.00	2.70	$p < 0.01$
Ending Sounds	8.89	2.77	6.78	3.13	$p < 0.01$
Phonics	10.20	2.54	8.89	2.70	$p < 0.01$
Phonograms	7.28	2.88	6.33	2.18	$0.01 < p < 0.05$

Table 4

Significance Levels of Tests of Reading Behaviors

Reading Behaviors Measured	Test*	Significance Level .01	.05	N.S.
A. Decoding				
1. Letter and Letter String Identification	1			x
	2	x		
2. Initial Sight Vocabulary	3		x	
	4p	x		
3. Word Decoding Skills	5	x		
	6	x		
	7		x	
	8	x		
	9p	x		
	10p	x		
B. Comprehension				
1. Word Meaning from Picture Cues	11			x
	12			x
	13	x		
2. Word Meaning - Vocabulary	14	x		
	15			x
3. Understanding of Syntax and Form Class	16p		x	
4. Sentence, Paragraph and Story Comprehension	17			x
	18			x
	19			x

Table 4 (cont'd)

	*Test	Number of Items
1.	C.A.T., Letter Recognition Test	24
2.	C.A.T., Reading Vocabulary-Word Form Test I, Section A	25
3.	C.A.T., Reading Vocabulary-Word Recognition, Test I, Section B	20
4.	Hartley Vocabulary Test	20
5.	S.A.T., Word Study Skills Auditory Perception of Beginning Sounds	14
6.	S.A.T., Word Study Skills Auditory Perception of Ending Sounds	14
7.	S.A.T., Word Study Skills Phonics - Recognition of Word from Spoken Cues	14
8.	S.A.T., Word Study Skills Phonograms - Rhyming Words	14
9.	Hartley, Phonetic Discrimination	40
10.	Hartley, Pronunciation Test	20
11.	Gates, Vocabulary Test - Picture Association	48
12.	S.A.T., Word Reading - Picture Association	35
13.	C.A.T., Vocabulary - Picture Association Test I, Section D	15
14.	S.A.T., Vocabulary	39
15.	C.A.T., Vocabulary - Meaning of Opposites, Test I, Section C	15
16.	Hartley: Form Class	20
17.	Gates, Comprehension Test	34
18.	C.A.T., Comprehension - Test 2	15
19.	S.A.T., Paragraph Meaning	38

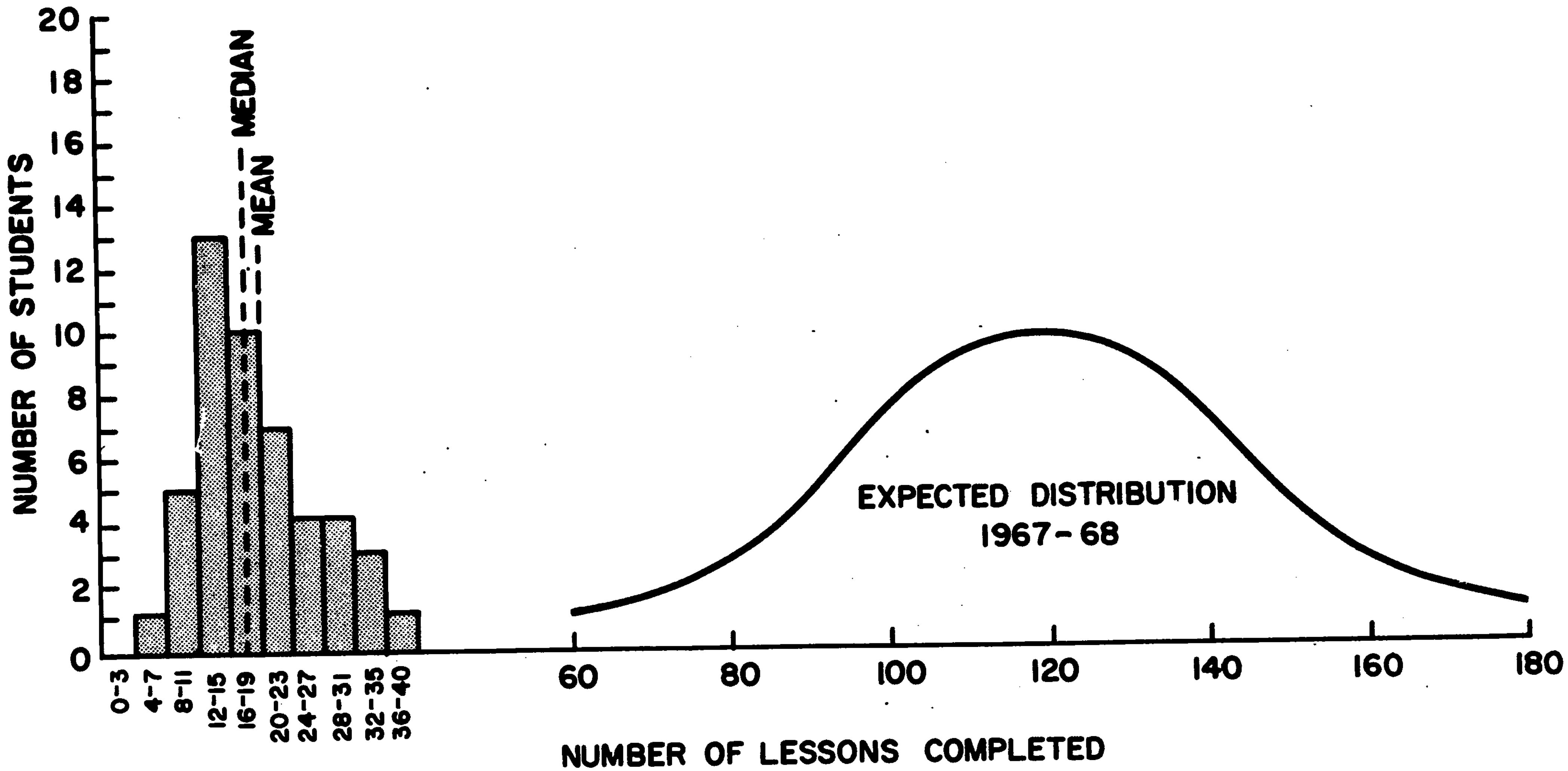

Figure 4. Number of lessons completed by students in the reading program, and expected 1967-68 distribution of lessons completed.

of paragraph comprehension. It must be noted that even the fastest student in this year's program had not reached the level in the lesson materials where exercises on the comprehension of connected discourse is introduced. It is also true, as stated earlier in this paper, that the comprehension exercises in the Stanford CAI curriculum are more of the nature of data gathering devices than they are a well-defined and complex teaching effort.

Projected distribution of students: 1967 - 68. An experiment was run during the last week of the 1966-67 operation in which all of the students were placed in selected lessons of advanced material where all known problems of branching structure, display formats, and audio search procedures had been corrected. The projected distribution of students at the end of the school year 1967-68, shown in Figure 4, is based upon that experiment. It is expected that the mean number of lessons completed by June 1968 will be 120 lessons with a range of 60 - 180 lessons.

3. Data Reduction for Mathematics and Reading.

The major activity of this reporting period has been the production and improvement of the daily and weekly reports for the mathematics group, the reading group, and the classroom teachers. During the second half of this reporting period, several programs were designed and created which will allow us to take a more detailed statistical look at last year's activities.

In preparation for an in-depth evaluation of our first year of operation, a major portion of our activity has been the reorganization of the student-response data. The most informative pieces of data have been taken out of their natural chronological ordering and reorganized. In some cases, they are arranged according to the student who had made the response; in other cases, according to the particular lesson on which the student was working.

B. Teletype Drill and Practice in Elementary Mathematics

The number of students enrolled in the drill-and-practice program increased from 877 during the previous reporting period to approximately 1500 in June. All students did not have daily lessons. In most cases the increased enrollment resulted from requests to add additional classes which ran on alternate days. Thus, though the number of students enrolled in the program nearly doubled during this reporting period, the average daily run remained relatively

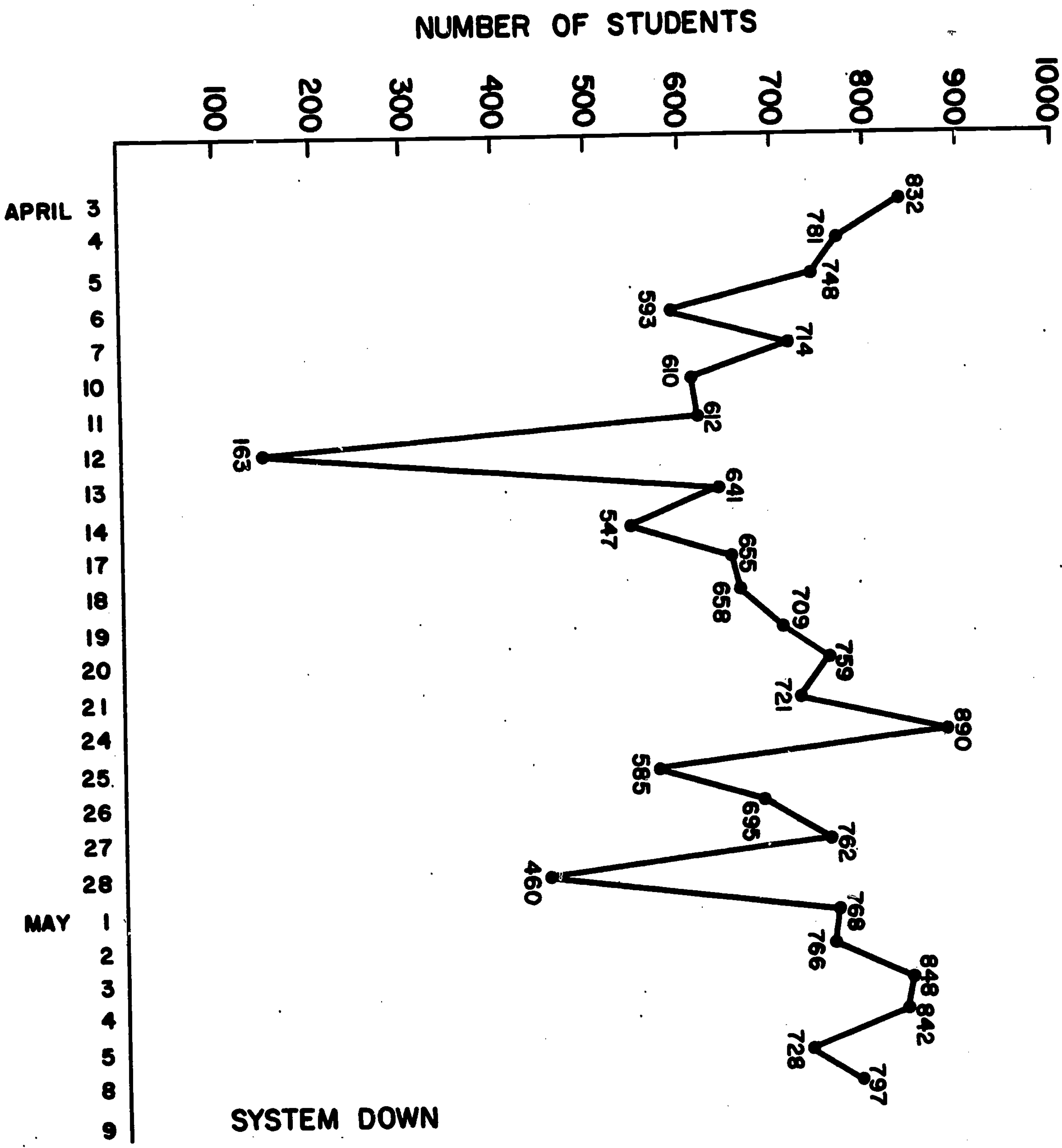

Figure 5. Number of users in teletype program, shown on a daily basis.

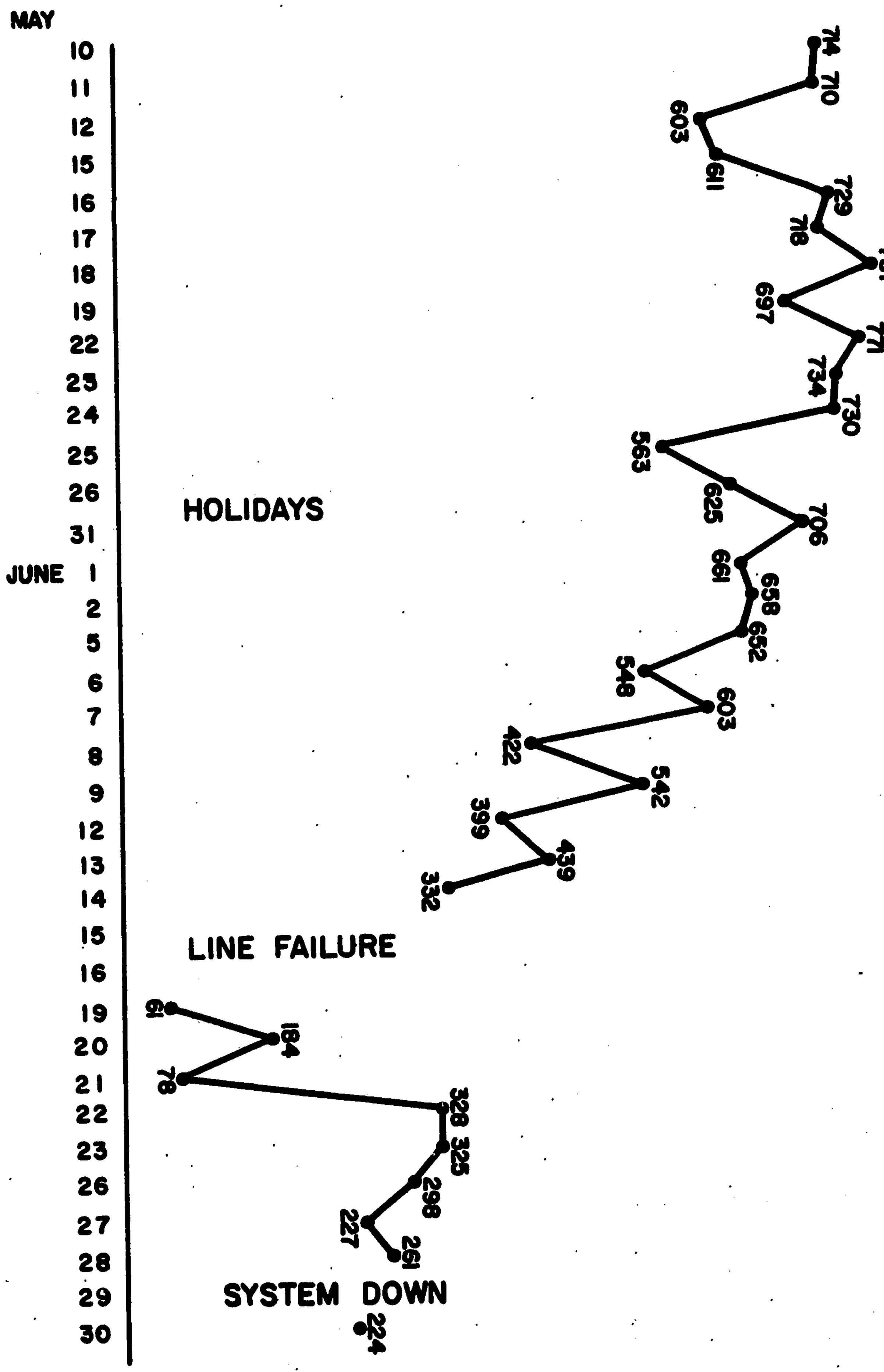

Figure 5. Number of users in teletype program, shown on a daily basis. (Cont'd)

constant. The total number of users is shown for each day in Figure 5 below.

Insert Figure 5 about here

These figures also include logic and algebra students.

The schools involved in the program up to June 15 were:

Grant School, Cupertino	grades 3-6, and 2 EHM* classes
Walter Hays School, Palo Alto	grades 2-6, and 1 gifted class of fourth graders
Oak Knoll School, Menlo Park	grades 1-3
Clifford School, Redwood City	grades 3-6
Ravenswood High School, East Palo Alto	grade 9, remedial arithmetic
Breckenridge School, Kentucky	grades 1-6
Elliotsville School, Kentucky	grades 3-6

Kentucky schools dismissed late in May and began summer sessions June 12. The number of machines was increased to 28 for the summer through the use of line concentrators which allowed all the machines in Kentucky to be operated over a single line from Stanford. During the summer session, Breckenridge School, a laboratory school at Morehead State University, will use the drill materials for grades 2 through 9. Rowan County School will use the drill lessons in grades 2 through 6. The Upward Bound Program will use grade 9 lessons. An adult education program will use drills for grades 5, 6, and 9. In addition, a teacher-aid program will be provided with fifth-grade lessons.

C. Teletype Program in Modern Algebra and Symbolic Logic

1. Class Progress

During the reporting period the class of selected fourth graders continued their work on logic and algebra. Thirty students at Walter Hays Elementary School in Palo Alto used the teletype daily for 6 to 10 minutes. Logic and algebra were presented on alternate days. Materials were developed and programmed for a complete course in sentential logic and the standard axioms of modern algebra. The two programs were progressively converged so that both sentential and algebraic steps appeared in many proofs. Also, the length of derivations was increased to as many as 17 lines. An outline of the lessons

* Emotionally Handicapped Minor

Table 5.

Sequence of Presentation of Consonant/Vowel Patterns

Consonant/Vowel Patterns

		vc	cvc	ccvc	cVc~~e~~ ccVc~~e~~ ccVc~~e~~	cV ccV	cvcc ccvcc	cvvc ccvvc	cvv ccvv cccvv	cccvc cvccc
L	I 13 lessons	ac	cac							
E	II 19 lessons	ic	cic	ccac						
V	III 23 lessons	ec	cec	ccic	cAc~~e~~ ccAc~~e~~	cA				
	IV 29 lessons	See Note 2.								
E	V 23 lessons	oc	coc	ccec	cIc~~e~~ ccIc~~e~~	cI cY cE ccY ccE	cacc			
L	VI 36 lessons	See Note 2.						ai oo ight	ay	
S	VII 43 lessons	uc	cuc	ccoc	cEc~~e~~ cOc~~e~~ ccOc~~e~~ cUc~~e~~ ccUc~~e~~	cO ccO	cicc cecc ccacc ccicc ccecc			a ccc i c a e c i ccc e
	VIII 65 lessons	See Note 2.		ccuc			cucc cocc ccucc ccocc	ow oy ee ie ea ei ew		o cccuc cuccc o

Note 1: c = any consonant; v = any short vowel; V = any long vowel.
Note 2: Less frequent and less regular variations of preceding patterns (e.g., post-vocalic r, w, etc.)

in sentential logic and in modern algebra follows. Table 6 shows the range and mean number of problems completed by the students during the reporting period. Table 7 shows the median point reached in the logic and algebra

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Insert Table 6 about here

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programs, and the range of the points reached in each program. A combination of hardware and program difficulties during the absence of our program-

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Insert Table 7 about here

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mer forced us to limit the program to the algebraic derivations during the final two weeks of school. The teletypes were used for a total of 43 days. An average of 23.8 students per day used the machines. The number of users was limited by student absences and machine difficulties.

2. Algebra Program

<u>Curriculum description.</u> Students derived simple algebraic facts using

a. the commutative law for addition

b. the associative law for addition

c. a definition of number, and

d. rules which allowed replacement of a number with its definition and replacement of the definition with the defined number.

At the teletype the student was asked to derive algebraic facts. Instructional material was presented both on the computer and in the form of a semi-programmed text which the students had available at the teletype. The text was used in the following way. Upon reaching a new lesson in the curriculum, the program would type a message to the student telling which part of the text he should work through before continuing at the teletype. Table 8 shows the number of problems in each lesson presented, the cumulative number of problems completed by the end of each lesson, and the new rules introduced.

Insert Table 8 here

<u>Progress in curriculum and program writing</u>. During the quarter the curriculum writer continued to log in curriculum on computer files for use by the algebra program. Debugging was also carried out to determine that the lessons were properly logged in. The curriculum writer also began work on a computer program designed to analyze data received from the algebra program. In addition to determining latencies on student performance, the data analysis program will organize student proofs into classes of proofs. These classes of proofs are of interest in analyzing how the students solve the problems, that is, what steps they choose to do the proof.

3. Logic Program

<u>Procedure</u>. A trained logician was present to give on-line individual help as needed. The help was standardized as much as possible and records kept of any instruction given. Brief instructions were typed out for the student. The most frequently used response mode required the student to type abbreviated rule names and the numbers of the lines to which the rules were applied. The machine responded by typing the result of applying the rule, or it typed out an error message explaining why the rule could not be applied as specified. The other response mode programmed at the end of March was that of multiple choice. This was used in vocabulary drill and studies of strategy, and to reinforce the reading of instructions. During this reporting period individual help was restricted and students were encouraged to work independently. Results of this procedure were highly satisfactory.

<u>Lesson content</u>. Table 9 shows the number of problems in each lesson presented, the cumulative number of problems completed by the end of each lesson, and the new rules introduced in each lesson.

Insert Table 9 about here

D. Elementary Russian Project

1. Computer-based Russian Comprehension Experiment.

A pilot Russian comprehension experiment was conducted as planned. Our ten pilot subjects were Stanford graduate students, only one of whom had knowledge of Russian. All ten of the pilot subjects were well acquainted

Table 6. Number of Problems Completed in Symbolic Logic and Modern Algebra

	Mean	Range
Logic	56.5	34 - 87
Algebra	97.3	67 - 120
Total	153.6	107 - 203

Table 7. Point Reached in Program

	Median	Range
Logic	Lesson 10, prob. 25 1/2	Lesson 8, prob. 9 to Lesson 14, prob. 6
Algebra	Lesson 91, prob. 5	Lesson 87, prob. 4* to Lesson 93, prob. 16

* one student at Lesson 87, prob. 4; next at Lesson 89, prob. 1

Table 8. Algebra Lessons, Number of Problems, and Rules Introduced

Lesson	Number of Problems in Lesson	Cumulative Numbers of Problems Completed by End of Lesson	Rule Introduced
80	10	10	New number definition
81	15	25	Number definition
82	20	45	
83	15	60	
84	20	80	Commute addition
85	23	103	
86	22	125	
87	13	138	
88	20	158	Associate addition to the right
89	21	179	
90	11	190	
91	20	210	Inverse definition
92	17	227	
93	17	244	Associate addition to the left
94	21	265	One literal number in expression
95	17	282	Two literal numbers in expression
96	20	302	Commute multiplication
97	20	322	
98	14	336	
99	20	356	Associate multiplication to the right
100	30	386	Associate multiplication to the left, distribute right, and distributive law
101	29	415	Zero law
102	30	445	Inverse zero law

with the concepts and mechanics of computer-based instruction. Questionnaires were administered to these subjects after each experimental session. Their comments, together with our own observations and data analysis, allowed us to make substantial revisions, modifications and improvements in both experimental material and the computer program.

Following these changes, the experiment proper began with undergraduate students, who had no knowledge of Russian, as subjects. We plan to run a total of 40 subjects. Thirteen have already been run. The progress report will include findings with these 40 subjects.

The equipment used in the experiment included the PDP-1 computer, Philco READ displays and keyboards, CRT visual displays with light pen, and Westinghouse audio units (prodac-50).

2. Computer-based First-year Russian Course

The development of our computer-based first-year Russian course is proceeding as planned. Thirty machine sessions have been completely outlined. Each outline specifies the sequence of vocabulary items and grammatical points to be covered in that particular lesson. A manual and a coding scheme for the lesson programmers have been compiled. Three lesson programmers have been trained and are currently generating the actual texts of the sessions from the outlines. Twenty sessions have already been written. Of these, eight have been entered, corrected, and run through the first preprocesser. These lessons are ready to be recorded on tapes and tested on students. The remaining 12 lessons are being entered and corrected. So far there have been no delays, and work has been completed according to schedule.

Preparation of processer programs. Two programs have been written to process the text written by the lesson programmers. The first operates on the code symbols used by the lesson programmers to convert the coded text to a complete text of the session, consisting of a series of audio and teletype messages to the student and the typed responses he is to make. This text will serve as a script for recording audio messages. The second program converts the output of the first to machine language instructions used by the computer itself. Only the first program is debugged, but the second will be ready by the time the audio equipment is received.

As soon as the first Ampex tape recorder is received (see equipment used, below), recording of the lessons will begin and student copies will be made from the original master tape. The testing of the first lessons with pilot subjects will begin immediately thereafter and will continue for a final check of the material, programs, and hardware.

Preparation of course text. Each quarter, students in the computer-based course will receive the same final exams as students following the conventional course. This will allow a preliminary evaluation of the respective merits of the two methods of teaching. Extensive analysis of the data obtained during the learning in our course will furnish us with more detailed information of great practical and theoretical significance.

Equipment used. The six teletypes ordered from the Teletype Corporation, Model 3S, have been installed and are operational. Each has a cyrillic alphabet set on the keyboard, and types in both Russian and English. In the second week of June, tape recorders were ordered from the Ampex Corporation. They are described in Table 10.

Insert Table 10 about here

Item 1 will be used for recording. Items 2 and 3 will be installed in the student stations. In addition, item 2 will function as an auxiliary recording machine whenever the main recording machine is being serviced. All items will be installed and in operation well in advance of the fall quarter.

E. Systems and Operations

1. Stanford-Brentwood 1500 System

Hardware. Our original 1442 card read punch continually gave us trouble. We requested and received a mechanical replacement. The new 1442 has, in general, operated quite well. There have been periods when it gave many punch checks, but it has done a better job than the original 1442.

The original order for the 1500 system specified 2402 Model 2 magnetic tape units (60KC). There were none available, so our system was delivered with Model 3 tape units (90KC). At the end of May we received the Model 2

Table 9. Logic Lessons, Number of Problems, and Rules Introduced

Lesson	Number of Problems in Lesson	Cumulative Number of Problems Completed by End of Lesson	Rule Introduced
1	19	19	Affirm the antecedent
2	8	27	
3	7	34	Affirm the antecedent: two-step derivations
4	15	49	Form a conjunction
5	21	70	Left conjunct; right conjunct
6	20	90	Deny a disjunct
7	21	111	Deny the consequent
78	20	131	Multiple-choice vocabulary drill (given to all students at the first of the reporting period)
79	19	150	
8	17	167	Double negation
9	21	188	Hypothetical syllogism (first problem using both sentential and algebraic rules)
10	27	215	Form a disjunction
11	17	232	Extensive sentential-algebra, multiple-choice
12	18	250	Commute disjunction; commute conjunction
13	27	277	English by multiple-choice mode
14	16	293	Dominance; conditional, antecedent, consequent, English conditional
15	25	318	Conditional proof
16	20	338	Omitting some parentheses; denial as one-place and as two-place predicate
17	24	362	Indirect proof

Table 10

Item	Qty.	Description
1	1	AG-440-2 in Console Mount 3-3/4 to 7-1/2 ips
2	1	AG-440-2, Rack Mounted 3-3/4 to 7-1/2 ips
3	5	AG-445-2, Rack Mounted 3-3/4 to 7-1/2 ips

units, and the Model 3 units were returned. After installation of the Model 2 units, we experienced a severe writing problem. The difficulty was traced to two cards in the drive 1 write circuitry. Once these cards were replaced, the tape units ran without trouble.

The disk drives became misaligned and caused difficulty for a few days. The 1802 memory had some adjustment problems; and four logic cards in the addressing unit went bad.

Most of the above hardware problems occurred in a three-week period at the end of May and beginning of June. The hardware trouble caused much frantic activity and many late nights for the Systems personnel, but very little student time was lost. The production operation was most hard hit.

The terminal gear has been running quite well. There have been isolated problems at the stations, but they never caused the entire system to go down.

Software. In mid-June we received a new version of the operating system which treats defective disk cylinders in a more efficient way than the previous version of the system. The new system uses a defective cylinder table in sector 0 instead of setting up "holes" in the work file to bypass bad cylinders.

Just before the new system was installed, we completed a pack-to-tape-to-pack program which enables us to keep all but immediately needed lessons on tape. Since this program allowed us to be tape- rather than disk-oriented, the installation of the new system involved very little disk pack conversion. We did, however, have to redo the disk and file handling subroutines for off-line programs. During this modification we added a garbage-collect routine to the file handlers to collect adjacent free files on the disk and hence make more efficient use of disk space.

The course segment reassembler has been modified to be more efficient and reliable.

The CAI character and graphic dictionaries have been modified to allow combined debugging of mathematics and reading lessons.

When the new operating system was installed, the Coursewriter II 'don't care' character was changed from X to alternate code X, to avoid confusion with the 'x' multiplication character.

2. Stanford PDP-1 System

The special hardware interface for the DEC-tape magnetic tape drives was completed. Appropriate software changes in the time-sharing system now allow tape operations to be performed simultaneously with normal time-sharing activity.

Two PDP-8-680 systems were delivered and accepted at the Stanford Laboratory. Initial PDP-8 programming, the PDP-8/PDP-1 hardware interface, and modifications of PDP-1 software were completed with both PDP-8's operating at Stanford. One PDP-8 was then shipped to Morehead, Kentucky for final installation and debugging. After initial delays in installation of the leased telephone line between Stanford and Morehead, routine on-line operation began June 19, with 27 teletypes in service. This initial operation provides for multiplexing teletype input and output over a single high-grade line, simultaneous use of the PDP-8's console teletypes as an intercom link between Stanford and Kentucky, and remote PDP-8 program loading from Stanford over the phone line. The PDP-8 programs are edited and assembled using the PDP-1 time-sharing system and loaded directly into the core memory of the local PDP-8.

Portable teletypes with acoustic couplers are now being used routinely through the two data-phone connections to the PDP-1, allowing access to the computer from any ordinary telephone. Two such teletypes were used on a daily basis in Morehead, Kentucky through May and June, until operations were shifted to the PDP-8 multiplex system. Demonstrations of the teletype-drill system were conducted via acoustic couplers in St. Louis, Salt Lake City, Las Vegas, Chicago, Montreal, and Albuquerque. This technique has proved far more satisfactory than use of the TWX teletype network.

During this period an analysis of the future computer system requirements of the Laboratory was undertaken, and a preliminary survey of available equipment was initiated. To meet commitments for the latter part of 1967, an additional 64,000 words of core memory were ordered to be interfaced through special hardware to the PDP-1 and PDP-8. This extra core memory will be used for real-time data storage to cut down access demands on the disk file. It will furnish a prototype operation for future techniques of handling large numbers of teletypes. Negotiations were also initiated for expansion and later replacement of the disk system.

Twenty-two teletypes and a PDP-8-680 system capable of operating 20 teletypes on-line were ordered for installation in McComb, Mississippi.

A leased telephone line between McComb and Stanford and additional line interfacing for the Stanford PDP-8 were also ordered to permit a mode of operation similar to that now employed for Kentucky.

Two of the local leased lines were moved from Ravenswood High School in East Palo Alto to Roosevelt Junior High School in San Jose, California for operation during the summer session.

Print boxes and keyboard caps using a Russian character set were received for the Model 35 teletypes used in the Russian program at Stanford.

II. Activities Planned for the Next Reporting Period

A. Brentwood

1. Mathematics

Writing, coding, art production, audio recording and debugging of second-grade material will be the major activity of the next reporting period. Analysis of first-grade data will continue.

2. Reading

The lesson programmers will continue coding and debugging the lesson material in Levels IV and V. They will also revise Levels I and II in order to correct known problems that could be remedied only when children were not running on the machines. This revision will eliminate redundant audio, improve audio search procedures, and revise restart points.

The writing staff will revise the introductory lessons and design lessons to teach letters by using a newly acquired function capability. The staff will also develop a teacher's manual. Four Brentwood teachers will assist the staff with the manual during a six-week workshop.

3. Data Reduction

For the next reporting period we plan to use the reorganized data to conduct an in-depth study of our first year of operation. The data reduction group will also be involved in activities designed to facilitate the study of next year's operations.

B. Teletype Drill and Practice in Elementary Mathematics

Two teletype machines will be used in Roosevelt Junior High School in San Jose, California beginning June 26. Lessons for grades 5, 6, and 9 will be provided for Mexican-American children in remedial arithmetic classes.

During the next reporting period a four-week teacher-training workshop will be held at Stanford for Mississippi teachers who will be involved in the project in September. Summer schools will continue until August 11, after which modifications in program and teacher reports will be made in preparation for the expanded operation in the fall. Work on test results for the past year's program should be completed during this time also.

C. Teletype Program in Modern Algebra and Symbolic Logic

At the end of the quarter a revision of the program was planned to be used with a new group of beginning students in the fall of 1967. Students in grades five through eight will participate in a teletype program at five California schools: Oak Knoll School in Menlo Park, Clifford School in Redwood City, Walter Hays School in Palo Alto, Grant School in Cupertino, and Garden Oaks School in East Palo Alto. It is expected that our experience this year will enable us to write materials for which the students will need a minimum of instruction or help from a teacher.

During the next reporting period, the lessons for the revised program will be written in complete detail and programmed for the computer. In the program, sentential and algebraic deductions will be completely integrated into one program.

New topics will be introduced in multiple-choice mode. This mode will be used for vocabulary drill, strategy suggestions, and hints. In general, a few simple one-step derivations will be given using each new rule. Then there will be a few multiple-step proofs using the new rule, followed by derivations using any of the rules already presented. These will include English examples, symbolized sentential derivations, derivations requiring both algebraic and sentential rules, and purely algebraic derivations. All will be interspersed with problems in the multiple-choice mode. In sections with longer problems, occasional short problems will be inserted. Table 11 shows the schedule for lesson completion.

Insert Table 11 here

Table 11. Lesson Completion Schedule
for Revised Algebra and Logic Drills

Date	Lesson to be Completed
May 8	2
15	4
22	6
29	8
June 5	10
12	12
19	16
26	20
July 3	24
10	26
17	29
24	32
31	36

The concept blocks have also been planned for the revised material to be used with beginning logic students.

In addition, an extension of the fourth-grade algebra-logic curriculum will be prepared for the fifth grade. This program will unite the logic and algebra into one curriculum. The program will give the students a set of axioms for the field of rational numbers. With this set of axioms and logical and non-logical rules of inference and definitions, the students will prove properties of the field of rational numbers. These proofs, as well as the instructional material, will be done exclusively at the teletypes. Because of extensive changes in the computer program, it will not be necessary to supplement the program with instructional material in the form of an off-line text. Extensive use will be made of hints and multiple-choice problems for instruction.

It is planned that students occasionally will construct their own theorems and prove them on-line. These theorems will then be available for use in future proofs.

Off-line instruction in the classroom will consist of problem-solving exercises related to the axioms and theorems proved on-line. Students will be required to use the axioms and previously proved theorems in these problem-solving exercises.

Further off-line instruction will include illustrations of properties of the field of rational numbers by use of the notions of a number line, co-ordinate system, transformations, rotations, and reflections. Approximately 29 students will participate in this program.

D. Elementary Russian Project

We will finish running subjects in the Russian comprehension experiment and will analyze the data obtained. We will also continue the development of the Russian course and will run pilot subjects prior to the beginning of the fall quarter at Stanford University in September, 1967.

E. Systems and Operations

1. Stanford-Brentwood 1500 System

TSX has been used for all Fortran programs. Since there have been many problems with TSX, analysis programmers have experienced great difficulty in using that system. In order to alleviate the problems, we plan to expand our batch monitor to include Fortran capability and to allow subroutines for both Fortran and assembly language to reside on the monitor disk. This expansion will be a major activity for the summer.

2. Stanford PDP-1 System

The number of on-line teletypes in Morehead, Kentucky will be increased to 32, and all teletypes will be modified to permit turning the motors on and off by remote control from the PDP-1. This technique should significantly extend the service life of each teletype, as well as improve centralized control over the teletype network.

A 100-circuit cable will be installed between Pine, Cedar, Casita, and Ventura Halls on the Stanford campus. It will allow use of teletypes outside of the Pine Hall computer area without the need for telephone lines and data sets. Initial use is planned for the McComb Teachers' Workshop and the Stanford Russian program.

Negotiations will continue on expansion and replacement of the disk file, and for GSA service-sharing facilities on the long-distance telephone circuits. A request for proposals will be issued to several manufacturers for expansion of the central computer facility, and negotiations will be started for obtaining equipment for use in September, 1968.

A PDP-8-680 system and teletypes will be installed at McComb, Mississippi and connected to the PDP-1 via leased phone line. Additional core memory will be installed for the PDP-1 and the time-sharing system. The drill program will be modified to make efficient use of the new memory.

Work will continue on a floating-point algebraic compiler for use in data analysis. Further efforts will be made to maintain and improve system reliability. The PDP-8 program will be refined to allow more sophisticated message handling and error-recovery techniques on the multiplexed network. The two leased lines to Roosevelt Junior High School in San Jose, California will be moved to another school within the same district.

Demonstrations via acoustic coupler are presently scheduled for Chicago and Berkeley.

III. Personnel

A. Brentwood

1. Mathematics

Patricia Clute and Constance Ihrke have joined the staff as teachers. Two new coders have been added to the staff: Joanne Bergel and Lucy Steele. One coder, John Prebus, was transferred to a position as a programmer for the Systems Group.

Several part-time and full-time teacher-consultants and coders have been hired for the summer.

2. Reading

During this reporting period, Helen Perigo, Janet Snyder, and David Miller have joined the staff as full-time lesson programmers. John Steers was hired as a half-time lesson programmer.

Two artists, Sybil Selldorff and Beth Jensky, have left the project. The reading project is now contracting with two commercial firms for continuing art production.

3. Data Reduction

There has been no change in the Data Reduction Group's staff.

B. Teletype Drill and Practice in Elementary Mathematics

Margaret Cochrane has been added to the permanent staff, and Ann Ukena has been added for the summer.

C. Teletype Program in Modern Algebra and Symbolic Logic

James Newland will replace Constance Ihrke as instructor for the class. Mr. Newland is planning the off-line instructional material.

D. Elementary Russian Project

Staff additions during this reporting period are an input coder, Dr. Elizabeth Popova, and three lesson programmers, Robert Sholiton, Constance McClintock, and Sandra Frederick.

E. Systems and Operations

1. Stanford-Brentwood 1500 System

Gilbert Smith, graveyard shift computer operator, resigned. He has been replaced by John Johnston.

To augment Mr. Johnston's six days a week of production, William Wilson was hired part-time to run production Saturday nights. Mr. Wilson, being a graduate student, left for summer vacation in mid-June. He has been replaced by Deirdre Thorne, who works Sunday afternoons rather than Saturday nights.

Roulette Smith, three-fourths time systems programmer, transferred to the logic-algebra group in the Institute. He has been replaced by John Prebus, formerly a coder with the math group. Mr. Prebus works full-time.

To alleviate the need for the curriculum groups to provide a machine proctor for student sessions, and to keep better track of terminal hardware problems, the Systems and Operations Group will acquire a full-time machine proctor, by either hiring another person or shifting an existing member of the staff into that position.

2. Stanford PDP-1 System

Joan Freed was hired for the summer as a lesson coder, returning to the position she held the previous summer. Kathleen Thompson was hired as a part-time lesson coder for the summer, having had considerable previous experience with the project.

Janice Stone and Jean Brief resigned their positions as computer programmers.